

SP-F2 Evaluation of Project Effects on Fish Diseases

~~May 10~~June 26, 2002

1.0 Introduction/Background

As mitigation for the loss of salmonid habitat due to construction of the Oroville Facilities, DWR constructed the Feather River Hatchery (FRH). Millions of spring-run and fall-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) have been released from FRH, providing significant contribution to the commercial and recreational harvest, both in the ocean and inland fisheries. (DWR 2001)

Several endemic salmonid pathogens occur in the Feather River Basin, including *Ceratomyxa shasta*, *Flavobacterium columnaris*, infectious hematopoietic necrosis virus (IHNV), *Renibacterium salmoninarum* (bacterial kidney disease [BKD]) and *Flavobacterium psychrophilum* (cold water disease). While these pathogens occur naturally, the Oroville Facilities, as well as other dams, water withdrawals, agriculture and silviculture, may have produced environmental conditions that are more, or less, favorable to these pathogens as compared to historic conditions. Impediments to migration may have altered the timing and the duration of exposure of anadromous salmonids to certain pathogens. Fish management practices, such as introductions of exotic fish species, hatchery production, and out-of-basin transplants, also have inadvertently introduced foreign diseases (such as whirling disease). Water management activities such as transfers, pump-back operations, and flow manipulation can result in water temperature changes and/or increased fish density, and thereby increase the risk of disease.

Project facilities and their operations may also reduce the transmission and extent of some fish diseases. For example, during the late spring and summer, the project releases cooler water into the Feather River low flow channel than existed historically, thereby providing more favorable conditions for the control of diseases, such as ceratomyxosis, in the steelhead populations residing in the river. In addition, the project facilities are utilized to provide desirable temperature conditions in the ~~Feather River Hatchery~~FRH, which Temperature control is one of the most important methods in regulating diseases such as IHNV at the hatchery.

Little is known about diseases and pathogens of non-captive fish in the Feather River basin. Extensive records of hatchery-reared salmonids exist, and inferences for wild fish diseases are appropriate. Of the fish diseases occurring in the Feather River Basin, those that are main contributors to fish mortality (e.g., IHNV, BKD, *Ceratomyxa shasta*) are of highest concern for fisheries management in the region. Although other diseases associated with parasitic copepods (e.g., gill maggots, *Salmincola californiensis*, anchor worms, *Leamnea* sp.) and other ectoparasites (e.g., *Epistylis* sp., *Ichthyobodo* sp., *Gyrodactylus* sp.) may occur in Feather River fish, they do not necessarily lead to fish death nor threaten fish populations in terms of increased mortality. Thus, they may be considered less important for the management of the Feather River fisheries. Hereinafter, the use of the adjective “significant” will be restricted to those diseases or vectors that are important for the management of the ~~Feather River hatchery~~FRH and fisheries because of their contribution to Feather River fish mortality. The pathogens and parasites listed above are by no means a complete listing for the Feather River basin.

IHN resulted in significant mortality at the Feather River Hatchery. In 1998, 2000, 2001, and 2002 several million juvenile chinook died as a result of IHN (DWR 2001). The infectious hematopoietic necrosis virus (IHN) causes significant disease in ~~-~~chinook salmon, kokanee salmon, steelhead, and rainbow trout. IHN infectivity is increased when water temperatures fall below 60°F. Since 2000, IHN issues have caused the stocking of chinook and brown trout in Lake Oroville to be halted until further notice in order to protect the water supply to the ~~Feather River Hatchery~~FRH and the Feather River below the fish barrier dam. A plan to use coho salmon (*Oncorhynchus kisutch*) to stock Lake Oroville is currently under evaluation; coho salmon appears to be more resistant to IHN~~V~~ than other salmonids.

Ceratomyxosis is caused by *Ceratomyxa shasta*, an endemic myxosporean parasite that is lethal to many strains of rainbow trout and is prevalent in Lake Oroville (DWR 2001). Ceratomyxosis was first observed in 1948 in fall spawning rainbow trout from the Crystal Lake Hatchery in Shasta County, California.

The poor success of California Department of Fish and Game (CDFG) efforts at stocking rainbow trout in Lake Oroville in the 1970s and '80s are thought to be due to the prevalence of the infective stage of *C. shasta* in the lake. This parasite has a complex life cycle, which includes a common freshwater polychaete worm as an alternate host. Salmonids that are native to rivers where *C. shasta* naturally occurs have developed varying degrees of resistance to the disease through natural selection (examples are Pit River rainbow trout and Deschutes River steelhead). Likewise, salmonid populations that have not evolved with the parasite are highly susceptible to the disease. Resistance to the disease is heritable; offspring of a resistant parent and a susceptible parent have been found to have intermediate resistance to the disease. The progression of ceratomyxosis is influenced by water temperature. Mortality increases as water temperature increases above 50°F, though it has been documented in some drainages to be infective at temperatures below 43°F ~~-degrees~~ (Harza 2000).

Another potentially significant disease for Oroville Project waters is cold-water disease (*Flavobacterium psychrophilum*), the incidence of which is more serious in colder waters. *F. psychrophilum* is a Gram-negative bacterium known to affect wild and hatchery populations of virtually all salmonid species. This bacterium can cause mortality of up to 50 percent among young salmonids. Cold-water disease infection generally occurs at temperatures below 53°F. The classic forms of the disease involve the infection and necrosis of the caudal peduncle, followed by septicemia and death in larger fish, or anemia, splenomegaly and septicemia with high mortality rates for young fish.

BKD is a typically chronic disease caused by the Gram-positive bacterium *Renibacterium salmoninarum*. BKD is economically significant to salmonid hatcheries, especially with regard to Pacific salmon (*Oncorhynchus* sp.), because of its widespread distribution both in freshwater and saline environments, its chronic nature, which does not allow the disease to be diagnosed before late clinical or debilitating manifestations, its vertical transmission through sexual products, and the inefficacy of the main therapeutic compounds used in treating infected fish.

Whirling disease, a European disease introduced into North America in the late 1950s, is caused by the metazoan parasite, *Myxobolus cerebralis*. To date, whirling disease has caused severe damage primarily to wild rainbow trout populations in Montana and Colorado, but it impacts hatchery salmonids as well. *M.*

cerebralis was first detected in California in 1966, and is now found in many Central Valley drainages, including the Feather River. Although present in several watersheds in California, no adverse effects on salmon or trout populations have been observed in California (Modin ~~1988~~1998). This parasite has a similar life cycle to *C. shasta*. A very common oligochaete worm, *Tubifex tubifex*, serves as the alternate host. Native North American salmonids are more susceptible than European salmonids to the disease. Brown trout, which originated in Europe, have developed some resistance and may carry the parasite without succumbing to the disease. Infected brown trout are believed to release spores through fin erosion, and finally at death and decomposition. Also, spores survive passage through the digestive tract of piscivorous birds, and are spread through fecal matter.

Lake Oroville also supports a warmwater fishery. There is little information on the warmwater diseases present and their impacts on the fishery. However, many warmwater diseases could be of potential significance for Oroville Facilities waters, especially when water temperature increases above 50°F. These potentially significant warmwater diseases include anchor worms (*Lernaea* sp.), enteric redmouth disease (*Yersinia ruckeri*), and columnaris disease *F. columnaris*.

This study plan includes two-phases: a literature review and desktop study (Phase 1) and field surveys (Phase 2). Phase 1 will review relevant information on fish diseases of significance to Feather River Basin fish, and it will evaluate their potential impacts on Project reservoirs and on hatchery production and operations into the lower Feather River. The data collected in Phase 1 also will serve as a foundation for development of potential future protection, mitigation and enhancement measures (PM&Es). If significant data gaps are identified in the available knowledge base and indicate that significant potential risk exists, Phase 2 will consist of developing and implementing field studies to investigate specific Project effects on diseases in Project waters and obtain information that will be useful for developing potential future PM&Es. A decision to implement Phase 2 will require consultation with the Environmental Workgroup.

2.0 Study Objectives

The overall objective of the study is to evaluate the effects of ongoing and future Project operations (pump-back operations, hatchery production, water temperature, etc.) on the establishment, transmission, extent and control of IHN, BKD, and other significant coldwater and warmwater fish diseases. Significant diseases are (as defined earlier) those diseases that can cause serious losses to Feather River basin fish populations through increased direct, or indirect, mortality. Additionally, the study plan will establish tools to evaluate future potential operational scenarios and other protection, mitigation and enhancement (PM&E) measures.

Specific disease study objectives include the following.:

- Determine the occurrence and distribution of significant diseases in Project waters, including IHN, ceratomyxosis, BKD, cold water disease, and whirling disease (Task 1).
- Evaluate the potential for diseases to spread downstream in the Feather River (Task 1).
- Document the life history characteristics of the causative agents of the significant diseases and the mechanisms of disease transmission (Task 1).
- Document methods of controlling significant diseases (Task 1).

- For each significant disease, identify salient environmental conditions that impact disease transmission, e.g. high water temperatures (Task 1).
- Catalog historical and current fish species found within the study area~~Project area~~ and evaluate their susceptibility to diseases (Task 1).
- Evaluate the effect of hatchery operations on disease transmission within the study area (Task 2).
- Evaluate whether disease outbreaks in the study area may result from pumpback operations because of fluctuating environmental characteristics (Task 2).
- Evaluate the prevalence and potential for disease outbreak in the study area from current Project operations (Task 2).
- Review environmental characteristics of Project waters (i.e., from SP-F3.1, SP-F3.2, and SP-F10) to identify areas of management concern that have significant potential for disease outbreaks or disease transmission (Task 2).

3.0 Relationship to Relicensing/Need for the Study

The purpose of the study is to obtain and review existing information and to evaluate the Project's effects on the establishment, transmission and control of fish diseases. This information will be useful for evaluating direct, indirect and cumulative effects of the Oroville Facilities required to comply with the Federal Energy Regulatory Commission's (FERC) environmental review process under the National Environmental Policy Act (NEPA) and Endangered Species Act (ESA) consultation information requirements. This study is needed to collect and compile the baseline information regarding fish diseases in waters influenced by Project operations in order to evaluate potential project effects and to provide a foundation for development of future PM&Es.

Fish diseases are related to a variety of factors, including fish species, densities, the presence and amounts of pathogens in the environment, and water quality conditions, such as temperature, dissolved oxygen, and pH. The Project operations have the potential to affect all of these factors in the FERC Project waters, ~~Feather River Hatchery~~FRH, and the Feather River downstream of the Oroville Facilities and other waters in California. Of significance to disease issues are potential Project impacts to water temperature, Project and ~~facilities~~Project operations that include actions that might introduce diseases, such as out-of-basin fish transfers. During Phase ~~I~~1, a review of all available information will allow a preliminary assessment of the potential for Project operations to affect diseases in Project waters. If data gaps associated with high risk are identified in this phase, specific studies exploring direct relationships could then be undertaken.

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the ~~Federal Energy Regulatory Commission~~FERC application for license of major hydropower Projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the Project. The discussion needs to identify the potential impacts of the Project on these resources, including a description of any anticipated continuing impact for on-going and future operations. This study plan fulfills these requirements by evaluating potential Project effects on the establishment, transmission, extent and control of significant coldwater and warmwater fish diseases in Feather River and reservoir waters within the Project boundary.

4.0 Study Area

For purposes of identifying disease presence and prevalence, the primary study area downstream of the Project will encompass the Feather River upstream of the confluence of the Feather and Yuba rivers. Upstream of the Project, the geographic scope of the study area will be confined by fish passage barriers above Lake Oroville since these barriers represent the greatest upstream extent that diseased fish can travel. A secondary study area will be composed of areas where hatchery-origin fish are released within the Sacramento Delta and Bay areas (e.g., Benicia, Fort Baker, Tiburon), and areas within the migratory pathway of potentially infected anadromous fish. ~~Because these areas are outside of the region immediately affected by the Project,~~ As such potential impacts from hatchery releases or Project operations on risk of disease transmission or expression will be examined on a fish population level or assemblage and not on an individual fish ~~blage level. (work with this language)s (clarify what assemblage levels mean).~~

Study plans approved by the Environmental Work Group will define the limits of the study area. If initial study results indicate that the study area should be expanded or contracted, the Environmental Work Group will discuss the basis for change and revise the study area as appropriate.

5.0 General Approach

The first phase (Phase 1) of the study will entail a literature review (Task 1) to determine the presence and prevalence of endemic and introduced fish diseases in the Feather River Basin. This study plan will focus on significant fish diseases of highest management concern in the region, including IHN, ~~BK~~BKD, and C. shasta. This review will identify the documented disease outbreaks in these waters, the life history characteristics of the causative agents, mechanism of disease transmission, disease outbreak timing and duration, and control methods. A history of impediments to fish passage and fish transplants in and upstream of the Project and their origin (i.e., rearing facility) will be included to provide a comprehensive disease summary. Data collection and review will be coordinated with other fisheries study plans (see ~~s~~Section 7.0, Study Plan Coordination).

In Task 2, data will be gathered on Project operations, including ~~Feather River Hatchery~~FRH practices, and their influence on water temperatures, other relevant water quality parameters, and parameters significant to the spread and control of fish diseases. These efforts will be coordinated with the Project operations modeling, water quality and hatchery-effects study plans. This information will be combined with the analysis from the first task to evaluate how Project operations, including hatchery production and release practices, might affect the establishment, extent and control of diseases and documented outbreaks. Results will be organized to address: (1) the impact of reservoir diseases, (2) reservoir-hatchery interactions, and (3) the impact of reservoir and hatchery diseases on Feather River fish downstream of the Fish Barrier Dam and upstream Project waters, including potential to pass diseases upstream past Big Bend Dam during high water years. Throughout the process, data gaps will be identified. Recommendations for minimizing potential Project impacts on the establishment and transmission of fish diseases will be provided for use as tools in developing potential future PM&Es related to hatchery operations.

The Phase 2 analysis will entail specific field studies, if necessary, based on the data needs identified during Phase 1. Refinement of the studies will occur through consultation with agency personnel to identify and

prioritize fish management goals, as well as other data collection efforts that could potentially be combined with disease investigations. A final report will be prepared as the final task.

Detailed Methodology and Analysis

The two phases of the study plan have been divided into four tasks, as described below.

1. Perform Literature Review and Gather Data of Disease Presence;
2. Evaluate Project Impacts on Fish Diseases from Literature Review;
3. Initial Progress, Draft and Final Reports on existing data; and
4. Field Studies if determined necessary by Work Group.

Descriptions for the identified tasks and corresponding subtasks are provided below.

Phase 1

Task 1—Perform Literature Review and Gather Data of Disease Presence

Task 1 will gather and review existing information on diseases diagnosed in the Feather River Basin. This review will include a review of published literature as well as data available from recent unpublished or ongoing studies. Endemic and non-endemic pathogens present in the watershed, including the FRH, and their historic and current distribution will be identified.

To evaluate hatchery contributions, past and present DWR and CDFG fisheries management activities, including transplanting data and the origin of the stocks transplanted, will be reviewed. For each significant disease identified, the life history characteristics of the causative agent, mechanism for disease transmission, disease outbreak timing and duration, preferred habitats and control methods emphasizing significant problematic diseases such as IHN will be documented. For the pathogens determined to be present, this task will identify any alternate hosts, their life history and habitat preferences. We will catalogue historical and current fish species present in the study area, their basin-wide distribution and habitat preferences. Based on available information, we will document the presence and distribution of alternate host species required for the transmission of certain diseases and summarize historical and current fish passage and fish transplants in and upstream of the Project, as well as their origin (i.e., rearing facility). Specific references will include, but will not be limited to, the following:

- CDFG Health Lab Reports;
- Feather River Hatchery FRH Annual Reports;
- Coleman National Fish Hatchery Annual Reports;
- Crystal Lake Hatchery Annual Reports;
- Annual reports of other hatcheries in the Sacramento-San Joaquin Basin, that normally receive juveniles or eggs from FRH; and
- Interim data from IHN studies currently conducted by CDFG and the University of California;
- Current disease studies at the Feather River Hatchery FRH;
- Other ongoing disease studies which are related to significant diseases which occur in the Project Area (i.e. current Federal evaluation of IHN throughout the Western States);
- American River Hatchery Annual Reports;

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- Nimbus Hatchery Annual Reports; and
 - Mokelumne River Hatchery ~~a~~Annual ~~r~~Reports.

Fish health specialists from DWR, CDFG, and the California-Nevada Fish Health Center will be consulted. A report of the existing conditions of diseases in the basin will be produced. Results from the review will be organized by disease name, date and site of detection, ~~and~~ measures of incidence, and control of the outbreaks. Data gaps will be identified.

Task 2—Evaluate Project's Impacts on Fish Diseases from Literature Review

The objective of the second task is to review existing information on the environmental conditions of Project-affected waters with the potential to influence disease transmission and prevalence, (for example, fish prevalence in the diversion pool, their health status, and proximity to the water intake to ~~Feather River Hatchery~~ FRH), and evaluate how Project operations, including hatchery operations (i.e. disinfection methods, fish drugs/chemical treatments, river discharge, planting practices) and production, and pump-back operations, might affect the establishment, extent and control of diseases and documented outbreaks. Environmental data, including water temperature profiles, dissolved oxygen, pH, turbidity, and contaminant concentrations for each of the water bodies within and surrounding the Project area including Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay, Thermalito Afterbay, and the lower Feather River, will be reviewed, with a primary emphasis on water temperature. Concurrent studies on the hatchery effects on water quality (~~SP-W4~~) and Project effects on the temperature regime in Project-related waters (SP-W6) will provide information on the temporal and spatial trends in water temperature. Summary data of weekly or monthly water temperatures from Project waters from these studies will be required to qualitatively assess the impacts of temperature on the distribution and prevalence of fish diseases (Task 2 of SP-F2). Coordination with Project leaders for this study and water quality studies will occur at the initiation of the study to discuss data needs and data formatting requirements. The effects of water temperature on the rates of disease progression and meantime to death are well documented for many salmonid pathogens. In addition to water temperature, the Project has impacted other environmental parameters, including river flows, sedimentation, and fish habitat that in turn may alter the prevalence of certain pathogens and the distribution of fish.

Other information will be gathered as part of studies SP-F3.1, SP-F3.2, and SP-F10, which evaluate the effects of the Project on habitat quantity and quality for ~~resident-non-salmonid~~ and ~~anadromous-salmonid~~ fish, ~~respectively~~. Qualitative evaluations of habitat suitability for salmonids and other ~~resident-fish~~ species from these studies will be used to help assess the impacts of Project operations on the distribution and prevalence of fish diseases. Coordination with Project leaders for this study and habitat studies will occur at the initiation of the study to discuss data needs and data formatting requirements. Pump-back operations data at Thermalito and Hyatt power plants and data from several ongoing studies will be incorporated including:

- SP-E6, DWR temperature monitoring data for the lower Feather River, Thermalito Afterbay and ~~Feather River Hatchery~~ FRH at various water releases and operations;
- SP-F3.2, Spatial and temporal distribution of steelhead and chinook salmon rearing in the lower Feather River;
- SP-F10, Screw trap data recording chinook salmon emigration;
- SP-F3.1, Effects of water temperature on juvenile steelhead rearing; and

- DWR and CDFG fish habitat enhancement Projects.

A preliminary evaluation of the effects of the current operations of each Project facility on diseases potentially occurring and their impact to the fisheries resource will be produced. Project and hatchery operations data and timing of disease outbreaks will be analyzed. IHN evaluations conducted by CDFG and the University of California will be incorporated. Hatchery management practices with respect to fish health, and the efficacy of the ultraviolet sterilization system will be analyzed together with FRH release practices to evaluate the likelihood of transmitting disease from FRH infected fish to other wild or hatchery uncontaminated fish. This evaluation will require the review of reports such as Scott Foote's USFWS report on the likelihood of transmission of disease through release of chinook salmon from Coleman National Fish Hatchery, and in addition, some simulation techniques and cohort analysis to estimate the contribution of FRH production to Central Valley salmonid populations will be conducted as part of F9 Hatchery Effects on Salmonids. The results of these analyses are expected to be available in the summer of 2002 and will be incorporated in-to the fish disease assessment. This particular activity will be conducted through and require coordination with study plan SP-F9 Hatchery Effects on Salmonids. As we proceed with a review of all available information, data gaps will be identified and summarized. Assuming adequate information is available from Task 1, Task 2 will result in a complete evaluation of how the ongoing and future Project operations might impact fish disease transmission and expression, throughout the review and evaluation process. (Add additional text to clarify relationship with SP-F9 and use of information developed to assess ongoing and future operational scenarios):

For the sake of clarity, the review ~~and evaluations~~ encompassed in Task 2 will ~~be organized as four sub-~~ tasks include the following four evaluations:—. Each of these ~~subtask~~ evaluations will address ongoing and future operations ~~and~~ as well as possible changes in operations ~~that~~ that may occur.

- ~~Subtask 2A~~—Project's Impacts on Reservoir Fish Diseases and Hatchery Fish Diseases;
- ~~Subtask 2B~~—Impacts of ~~Feather River Hatchery~~FRH Fish Diseases and Operations on Reservoir Fish;
- ~~Subtask 2C~~—Impacts of Reservoir and Hatchery Fish Diseases, and Project Operations on Downstream Feather River Fish Populations; and
- ~~Subtask 2D~~—Impacts of Reservoir and Hatchery Fish Diseases and Project Operations on Upstream pPopulations.,

Task 3—Initial Progress, Draft and Final Reports

Initial progress, draft, and final reports will be completed for the review of existing information. These reports will include assessments of Project impacts where sufficient data exists. Information gaps and recommendations to address filling those gaps will be included. The initial progress and draft reports will be submitted to the Environmental Work Group for comments.

Phase 2

Task 143—Develop and Implement Field Studies

~~If data or information gaps are identified in-~~ The literature review and evaluation conducted under Tasks 1 and 2, will identify any significant data gaps or areas of high risk of disease transmission associated with current

Project operations. If data gaps or high risk situations are identified, we will first assess our ability to satisfy the necessary data need with a one year collection effort. Information on the data needed and potential data collection efforts will be conveyed to the Environmental Work Group. ~~a-~~If the Work Group makes a decision to pursue field efforts, Phase 2 study plans will be developed detailing specific criteria and appropriate methodologies for implementation. The studies will be refined through consultation with participants and agency personnel to identify and prioritize fish management goals, as well as other data collection efforts that could potentially be combined with disease investigations. Study plans will be implemented as directed by the Work Group. Results of any study will be written up into draft and final reports for review by the Work Group. The results of the field studies wouldwill be used as tools to develop potential future PM&Es related to Feather River HatcheryFRH operations.

Every attempt will be made to coordinate fish sampling with other ongoing studies such as:

- Steelhead snorkel surveys
- Steelhead and salmon beach seine surveys
- Rotary screw trap
- Creel surveys
- Chinook egg survival studies

If initial study results indicate that the methods and tasks should be modified, the Environmental Work Group will discuss the basis for change, and revise the study plan as appropriate.

6.0 Results and Products/Deliverables

Results

Results of the Phase 1 study will be used to evaluate potential Project impacts and evaluate potential measures that minimize potential impacts to fish as well as provide recommendations on relevant opportunities to protect, mitigate, or enhance fish resources in the Project area. The anticipated maps, tables, figures, and specific summary report elements include:

- Tables or figures summarizing fish transplants in and upstream of the Project and the origin of these transplants (Task 1);₁
- List of recorded disease outbreaks and pathogens detected (Task 1);₁
- Tables or figures that describe the life cycles of diseases such as IHN, ceratomyxosis, BKD, cold water disease, and whirling disease (Task 1);₁
- Figures that display the spatial locations of disease outbreaks and pathogens detected in and upstream of Lake Oroville (Task 1);₁ and
- Figures that spatially display potential disease “hot spots” based on environmental data obtained from other studies (Task 2);₁ and
- An initial progress report that identifies significant data gaps in the available literature and existing information. The progress report will be delivered to the Environmental Work Group by the end of October 2002.

In addition ~~to the above deliverables~~, a draft report will be delivered at the conclusion of Phase ~~I1~~. A final report also will be prepared at this phase if no Field studies are necessary. If field studies are implemented, the draft report for Phase ~~I-1~~ will become a chapter for a final report that includes descriptions of study methods, results, and conclusions. ~~The schedule for the draft Phase I1 report is for delivery to the Environmental workgroup Work Group in January 2003. The tentative schedule for each of the draft phase I report will depend on the time when the study is initiated.~~ Results from ~~the SP-F-2 progress~~ reports generated ~~during the disease study~~ will be used to guide PM&E measures and may be used in other studies to assess Project effects.

Products/Deliverables

A report will be prepared with each task or subtask of the study as a chapter in a larger report summarizing the Project's effects on disease establishment and transmission in the basin.

The first chapter will: (a) identify the presence and prevalence of significant fish diseases in the basin, (b) summarize life histories of the causative agents and mechanisms for transmission; and (c) provide a history of fish disease management in the study area and how fishery management has affected fish diseases. A map depicting the distribution of diseases in the basin will be included. A table will be produced summarizing the main characteristics of the diseases present.

The second chapter will provide an analysis of the Project operations that may affect fish diseases and describe how Project operations affect the establishment, extent, and control of the fish disease in the study area.

The final chapter will summarize the information gathered from the literature review and provide recommendations for minimizing or eliminating adverse Project-related effects on the establishment and transmission of fish diseases in the Feather River basin. Each chapter will be prepared as a draft and final product and will be distributed for review. If significant ~~-data gaps are -identified~~ throughout this process, ~~this it~~ will provide the basis for the Phase 2 study.

If a Phase 2 field study is necessary, the study methodology, schedule, and report products will be developed through consultation with participants and agency personnel. A final summary report will be produced whether or not Phase 2 is performed. The study plan summary report will include:

- Executive Summary,
- Table of Contents,
- List of Tables,
- List of Figures,
- Introduction,
- Narratives of relevant findings by task (specific elements to be included are listed for each subtask above),
- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns,
- Conclusions related to study plan goals and objectives,
- References, and

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- Appendices.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

A comprehensive evaluation of the potential effects of Project operations on diseases will require coordination with other relicensing studies. To minimize the cost of field collection and impacts to fish populations, fish sampling will be coordinated with any relicensing efforts conducted by DWR, CDFG, US FWS, NMFS, or other groups (University of California Davis) sampling fish in the study area.

Sampling activities would be coordinated during the development of detailed study plans for Phase 2 (Task 3). Information gathered during the following studies is relevant to the fish disease study and will be required to assess the history and status of diseases and habitat conditions in the basin.

SP-F3.1—Evaluation of Project Effects on Fish and Their Habitat Within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area. The characterization of fish, life stages and habitat, as well as the analysis results regarding Project effects on fish habitat quantity and quality, will provide information on current environmental conditions and fish populations that will be considered in assessing the risk and potential for disease transmission in Lake Oroville, the Thermalito Complex and Project waters upstream. Additionally, SP-F3.1 and SP-F15 will provide information related to existing fish passage conditions that is necessary to fully evaluate the risk of disease transmission in areas upstream of Lake Oroville. Additionally, SP-F3.1 will provide an evaluation of habitat that includes a description of habitat constraints upstream of Oroville Dam. Information on baseline environmental conditions is necessary for SP-F2 to adequately assess potential for disease transmission.~~**SP-F3.1—Evaluation of Project Effects on Resident Fish and Their Habitat Within Lake Oroville, the Thermalito Complex, and Upstream Areas Within the Project Boundaries.**~~ The characterization of fish, life stages and habitat, as well as the analysis results regarding Project effects on resident fish habitat quantity and quality, will provide information on non-current environmental conditions and resident fish populations that will be considered in assessing the risk and potential for disease transmission in Lake Oroville, the Thermalito Complex and Project waters upstream. be utilized in SP-F2.

SP-F4—Evaluation of Project Effects on Fish Passage Upstream of Lake Oroville. Study plan SP-F4 and SP-F15 will provide information related to existing fish passage conditions that is necessary to fully evaluate the risk of disease transmission in areas upstream of Lake Oroville and Project effects. Additionally, SP-F15 will provide an evaluation of habitat that includes a description of habitat constraints upstream of Oroville Dam. Information on baseline environmental conditions is necessary for SP-F2 to adequately assess potential for disease transmission, and constraints with regard to disease transmission.

SP-F5/7—Effects of Fisheries Management Plans on Project a-Balanced Fisheries. Study plan SP-F5 will provide information on existing and proposed management plans that will be evaluated to determine

how fisheries management activities may affect the establishment, extent and control of diseases, and documented outbreaks.

SP-F9—~~Hatchery Effects on Salmonids~~Evaluation of the Feather River Hatchery Effects on Naturally Spawning Salmonids. Study plan SP-F9 will provide basic information on FRH operations, release sites, and cohort analysis estimates of the contribution of FRH production to Central Valley salmonid populations. ~~This information will be essential for completion of Task 2 of SP-F2.~~

SP-F10—Evaluation of Project Effects on Anadromous Salmonids and Their Habitat in the Feather River Below the Fish Barrier Dam. The characterization of fish, life stages and habitat, as well as the analysis results regarding Project effects on anadromous fish habitat quantity and quality, will provide information on current environmental conditions and resident salmonid fish populations that will be considered in assessing the risk and potential for disease transmission. ~~will be utilized in SP-F2.~~

SP-W1—Project Effects on Water Quality Designated Beneficial Uses. Study plan SP-W1 will provide water temperature and water quality information that will be integrated in the evaluations of SP-F2 Task 2.

SP-W6—Project Effects on Temperature Regime. Study plans SP-W6 will provide water temperature and water quality information that will be integrated in the evaluations of SP-F2 Task 2.

Engineer and Operations Working Group Study Plans

- Model Development Study Plan, and
- Statewide Operations Model Development.

These plans will produce estimates of long-term annual and monthly flows and temperatures along the Feather River under different operation strategies that will be used by SP-F2 Task 2 to evaluate the impact of reservoir and FRH diseases on downstream Feather River fish populations.

The following studies will likely utilize results from SP-F2 as it is they are available. ~~the disease analysis conducted during this study (SP-F2).~~

SP-F3.1—Evaluation of Project Effects on ~~Resident~~ Fish and Their Habitat within Lake Oroville, its Upstream Tributaries, the Thermalito Complex, and the Oroville Wildlife Area. Study Plan SP-F3.1 will consider information germane to fish diseases in its evaluation of lotic environments (Task 3), lentic environments (Task 4), and in assessing potential habitat issues associated with ~~resident~~ fishes.

SP-F3.2—Evaluation of Project Effects on ~~Resident-Non-Salmonid~~ Fish and Their Habitat in the Feather River Downstream of the ~~Fish Barrier~~Thermalito Diversion Dam. Study Plan SP-F3.2 will consider information on disease agents, known hosts, disease transmission, methods of identification and diagnosis, and strategies for disease prevention. More specifically, the information from SP-F2 will be used in evaluating habitat conditions of the Feather River from the Fish Barrier Dam to the Yuba River confluence (Task 3), and in assessing the potential Project effects on resident-non-salmonid fish and their habitat.

SP-F9— Evaluation of the Feather River Hatchery Effects on Naturally Spawning Salmonids Hatchery Effects on Salmonids. Study plan SP-F9 will provide basic information on FRH operations, release sites, and cohort analysis estimates of the contribution of FRH production to Central Valley salmonid populations.

SP-F15— Evaluation of the Feasibility to Provide Passage for Anadromous Salmonids Past Oroville Facilities Dam. Evaluation of the Feasibility of Providing Passage for Anadromous Salmonids Past Oroville Dam. Study plan SP-F15 will provide an evaluation of habitat upstream of Oroville Dam and constraints with regard to disease transmission. Information from SP-F2 will be used during the description of reported responses from alternative passage and transport methods (Task 7) and in Task 3, which is to evaluate salmonids production fluctuations related to providing fish passage to upstream habitats.

SP-W6—Project Effects on Temperature Regime. Study plan SP-W6 will evaluate the temperature regime in Lake Oroville and Project effects to that regime from Project operations. In Task 1, potential disease considerations from existing temperature trends would be included in this evaluation. Task 2 (Downstream Temperatures), Task 5 (Hatchery Effects on Water Quality), and Task 6 (Pumpback Operations) also may use information from the disease study to describe impacts.

Issues, Concerns, Comments Tracking and/or Regulatory Compliance Requirements

The following table lists the issue number and summarizes the elements of the issue statement addressed by this study plan. Several of the issues, or certain elements of individual issues, may be addressed in other study plans. The master comment tracking database provides an indication of how each comment is handled.

Stakeholder Issues Fully Addressed by Effects of Project Operations on Fish Diseases Study Plan

Issue	Description
FE4	Have biologists describe the extent of viral infection in Lake Oroville
FE5	Would a fish screen(s) on the pump-back operation prevent Infectious Hemapoeitic Necrosis (IHN) and other diseases specific to Salmonid species from spreading and becoming permanently established in Lake Oroville? IHN, if permanently established in Lake Oroville, would affect survival of hatchery and river spawned Salmonid species
FE48	Evaluate potential of fish diseases spread from Lake Oroville to Feather River and back as a result of pump-back operation
FE49	Incidence of fish disease in response to temperature changes below dam

Stakeholder Issues Partially Addressed by Effects of Project Operations on Fish Diseases Study Plan

Issue	Description
FE25	Interaction of lake fishery with tributary fisheries
FE31	Several fish hatchery issues need resolution, such as the relationship between the hatchery and restoration of a natural ecosystem, straying and genetic impacts, harvest rates, and disease
FE82	Prior to construction of Oroville Dam, anadromous fish had access to the Poe Reach of the North Fork Feather River. These fish provided a source of energy to the river ecosystem. Construction of the dam severed this connection. There is an interest in determining the contribution of anadromous fish as an energy source for aquatic dependent species located in the North Fork Feather River and devising a strategy for replacing this loss
FE88	Impact of Hatchery Facilities and/or operations on anadromous salmonids. This includes the direct, indirect and cumulative impacts of hatchery products on anadromous salmonids and the direct, indirect and cumulative impacts of hatchery facilities and operations on salmonids and their habitats
FE99	The Feather River Hatchery (FRH) was constructed to mitigate for the losses of the upstream habitat when the Oroville Facilities were constructed. There is a body of evidence suggesting that improperly planned hatchery practices can adversely impact native and non-native species including anadromous species. The effects of hatchery practices on naturally reproducing/selfsustaining anadromous populations should be examined as part of the fishery investigations. These evaluations should examine alternative practices that would lead to increased naturally reproducing/selfsustaining anadromous populations. Improper hatchery practices can also lead to transmission of serious fish diseases, and impact overall susceptibility of naturally reproducing populations to diseases

8.0 Study Schedule

It is anticipated that the Phase 1 **Interim Project Report will be completed by October 2002 and the Final Report will be completed** by February 2003. A schedule for the Phase 2 study plan would be provided once a decision is made regarding the need and extent of the Phase 2 activities.

9.0 References

DWR 2001. Initial Information Package. Relicensing of the Oroville ~~F~~Facilities. Federal Energy Regulatory Commission License Project No. 2100.

Harza 2000. *Ceratomyxa Shasta* evaluation in the Cowlitz basin. Prepared for Tacoma Power.